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You heard Tom Meyer describe our work at ATO as "redefining the outer limits of warfare." In Anup's field, that connection is obvious. Information assurance goes to the heart of our ability to operate in an IT-dependent battlespace—and to interfere with the enemy's ability to do the same.

By contrast, communication for military operations is among the oldest requirements in the history of warfare, and a perennial focus for Defense research and development efforts. But just because the need is old doesn't mean the thinking applied to it should be.

At ATO, we have a series of projects underway—some approaching maturity, some in their early stages of development, and some new starts—that can offer our forces revolutionary new capabilities and expand the outer limits of warfare.

ATO's work in the communications field can be seen as a long-term effort to overcome problems in military communications. From a practical standpoint, that means better preparing and equipping U.S. forces for the three imperatives we confront in almost every modern overseas operation:

- Operations in distant theaters, far from where our forces traditionally have been stationed, often under conditions that we never seriously anticipated

- Coalition operations, not only with other NATO allies, but also side-by-side with forces with which we have little or no experience

- Need for warfighters to exchange real-time or near-real-time communication and data transmission about the battlespace

How are these imperatives driving ATO's communications programs toward specific, deployable solutions? Consider these examples:

In our peacekeeping operation in Bosnia, U.S. forces operated side by side with NATO and non-NATO forces. Here, the major challenge was setting up communications networks that could simply talk to each other, given the wide array of gear used by the various forces involved and in a radio frequency spectrum already occupied by civilian signals. That experience, and others like it, propelled ATO to develop capabilities to solve the problem of "adaptive spectrum utilization."

In Mogadishu, we found that Task Force Rangers' radio networks couldn't communicate adequately with supporting forces. Their equipment wasn't compatible, and there were conflicts with local, mainly civilian, communications. Moreover, buildings in the city blocked and interfered with transmission and reception. The result: commanders up and down the chain of command got an incomplete, confused, and distorted view of the situation on the ground. The hampered communications of our ground forces couldn't afford them a better or clearer picture. After-action analyses concluded that we needed to develop communications capabilities to afford a common operating picture of the battlefield, throughout the area of operations, and down to the level of the individual soldier.

Our current operations in Afghanistan have demonstrated our nation's need to extend our networks and exchange information about the battlespace. These operations have also illustrated the imperative of extending communications down to the individual soldier—now often the best "eyes and ears" in the hunt for the shadowy enemies we increasingly face.

To address these challenges of combat communications—spectrum deconfliction, the limitations of single function communications platforms, and expanding networks world-wide as well as down to the individual soldier—ATO's communications programs are focused on three main areas of development:

- Multiband efforts designed to enable existing single function platforms to interoperate, either among U.S. Services or among disparate coalition forces or even civilian sector users

- Multifunction efforts designed to supplement and eventually replace single-function platforms with software that can be programmed to operate with other communications gear. This kind of programmable, multifunction equipment can then perform a variety of roles: voice and data transmission and reception, COMINT (communications intelligence), ELINT (electronic intelligence), EW (electronic warfare), and even deception.

- Mobile, ad hoc networks that enable a range of systems operated by different users in the same battlespace to quickly assemble and operate voice and data networks automatically. These efforts aim to eliminate the time-consuming, manual surveys of the communications environment, frequency assignment, and deconfliction that are now required in preparation for operations.

ATO's communications programs often employ technologies that cross all three of these development areas. Here's a quick overview of some of the initiatives in the pipeline.

Our Adaptive C4ISR Node Program, more commonly known as the CAN, simultaneously tackles the multiband, multifunction, and mobile ad hoc networking challenges within a single program. The ACN is designed to provide a theater-deployable, airborne capability that can quickly and autonomously establish communications networks among existing, noninteroperable equipment and provide beyond-line-of-sight relay for combat radios. To accomplish this, we've had to achieve major breakthroughs in wideband and cochannel interference cancellation, wideband linear power amplifiers, and mobile ad-hoc adaptive networking. Its scalable, modular design enables us to deploy ACN on an array of platforms: pilotless vehicles and tactical aircraft pods, in addition to ground platforms. At the same time, its software-programmable architecture enables warfighters to perform simultaneously a wide array of missions, using the same modular equipment , including electronic order of battle, communications intercept, emitter geolocation, low-power jamming for electronic warfare, providing instantaneous voice and data connectivity to U.S. and coalition forces, and even low-power AM/FM broadcast of critical public information for civilians.

ATO's Future Combat Systems Communications Program primarily tackles the challenge of mobile, ad hoc networking on the battlefield, and doing so with high data rates while retaining low probability of detection and resistance to jamming. We achieve this by using, among other things, directional antennas on mobile vehicles. We have demonstrated the capability of this system to assemble itself and move around the battlespace while maintaining the integrity of its network and minimizing its communications signature. With these kinds of capabilities, FCS-C is expanding the outer limits of tactical communications available to U.S. forces.

SUO SAS—the Small Unit Operations Situational Awareness System —demonstrates our effort to extend communications and a common operational picture down to the individual soldier. The main technology thrust of this program is in multiband capability, although it also utilizes multifunction and mobile, ad hoc networking technologies. Once again, built on the backbone of software reprogrammable radios, SUO SAS will enable deployed forces to set up and maintain a voice and data network, including geolocation data, reaching down to the individual soldier. With SUO SAS, our soldiers will be able to relay information that provides an unprecedented level of knowledge about what is happening on the battlefield. This will allow small units to share information about emerging tactical threats and opportunities, reinforce each other, and call for needed support from higher echelons. And, apart from its battlefield uses, SUO SAS-type capabilities could be of enormous value in situations like the aftermath of September 11, enabling rescuers to accurately locate personnel and communicate individually with them without depending on a fixed infrastructure that can be damaged in such attacks..

Wolfpack is a logical extension of the capabilities we're working on in the FCSC and SUO SAS programs : mobile ad hoc networking, multifunction devices, and multiband operation. Wolfpack is a small radio frequency device, about the size of a Coke can, that can be sown around the battlespace from airborne or rocket-borne canister dispensers. In this case, we're aiming not so much to communicate with friendly

forces as to confuse and foil the enemy. Wolfpack devices communicate with each other once deployed so they can assemble themselves, ad hoc, into a network. But from there, their function changes. These small RF devices can be used to jam an enemy's radar or communications. Or they can simulate combat network communications among friendly forces, creating a tactical deception. Or they can serve as signals intelligence receptors, passing back what they collect up the chain.

Wolfpack is emblematic of the kind of work at which ATO excels: the unconventional deployment of extremely advanced technology to gain mastery of the battlespace.

The programs I've just described are in varying stages of maturity. Of course, at ATO, we are always pushing new ideas because modern warfare always provides new challenges and because science and technology are expanding the realm of the possible.

Let me conclude by briefly introducing two of the new efforts in ATO's inventory of communications initiatives. My goal is to illustrate some of the future directions of our research, and to spark some thinking about where your efforts and knowledge might complement our work.

One of the toughest problems our forces have faced recently is the challenge of communicating in dense urban areas, inside buildings or between adjoining streets when buildings interfere with line-of-sight communications. NETEX, Networking in Extreme Environments, is ATO's answer to this problem. NETEX is an ultra-wideband wireless networking capability that will enable us to communicate with troops inside buildings, in built-up areas, and in other challenging environments.

To make this work, we are launching a new initiative to investigate the interaction of ultra-wideband systems with other existing communications systems. This research will continue for the next 12 months. We hope the follow-on phases will extend for several years. Phase II, UWB Networking, and Phase III, Integration and Demonstration, will extend from the end of 2003 through the end of 2006. Our technical objectives in these phases are to achieve more than an order of magnitude reduction in the size and power requirements of the UWB equipment; improve the link margin by 20 dB; and develop ad hoc routing technology and protocols that will allow this equipment to operate not only with other UWB devices, but with existing communications equipment as well. What we will end up with is a new enabling technology for military operations in difficult RF environments or denied terrain. We hope many of you will have technology and ideas to help advance this effort.

Another new ATO communications program this year is THOR, for Tera Hertz Operational Reachback. Our objective is to supplement our overtaxed military satellite communications by taking advantage of the well-known global grid of fiber communications. THOR aims to fill in the missing links between the military air and space grids and the commercial ground grid with a network of laser communications that can readily interface with high-capacity fiber optics. By integrating laser-based communications with space and airborne assets and the terrestrial grid, we will be able to provide a real-time link from the battlespace back to the United States or, for that matter, to anywhere within our military grids. Phase I of THOR has just begun and focuses on developing the concept and architecture and sourcing the necessary technology. Phase II, focused on subsystem development, is planned to start in 2003 and last until the end of 2004. Phase III, technology integration and end-to-end system demonstration, is planned to begin in the last quarter 2004 and end with a final demonstration late in 2006.

How is ATO's communications program redefining the outer limits of warfare?

By building communications systems that talk to other systems they were never designed or built to operate with.

By developing radios that zero in on the frequency spectrum of only the radios they are supposed to talk to and automatically set up their own communications networks.

By bringing communications down to the level of the individual soldier and permitting the sharing of information about the battlespace.

By deploying dispersed radios that jam radars or transmitters or set up their own deception and diversion operations.

By seeking to harness and deploy communications that penetrate buildings and built-up hostile areas—communications equipment that doubles as SIGINT or EW gear—and sets itself up for its assigned mission.

This is the heart of our work in communications at ATO. It's interesting. It's challenging. It's a tremendous force multiplier for every U.S. combat arm. And, under the right circumstances, these technologies can help save lives in civilian emergencies.

With efforts like these we're getting closer to being able to, literally, "control the horizontal and control the vertical" on the electronic battlefield. We're looking forward to the contributions you can make to these programs.